RF Concepts
Alpha 8406 Linear Amplifier

User Manual

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Alpha 8406 Linear Amplifier User Manual

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1 Introduction

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Congratulations on your purchase of a professional-quality Alpha 8406 linear amplifier.

This manual contains information that you must follow, and cautions and warnings that you must heed, to ensure safe installation and operation. Before operating your amplifier for the first time, it is important that you study this manual carefully — in particular, the preparation, setup, and operation instructions.

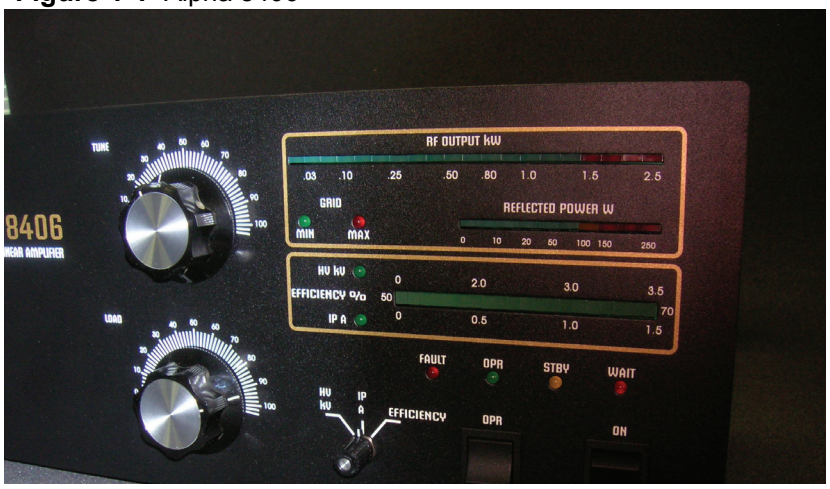
IMPORTANT

Failure to perform procedures properly may result in electric shock, fire hazard, or serious damage that is not covered under warranty.

1.1 Product Description

The Alpha 8406 (see Figure 1-1) is a self-contained manual-tune very-high-frequency (VHF) linear power amplifier.

Figure 1-1 Alpha 8406



1.2 Product Capabilities

Product capabilities are as follows:

- Continuous radio-frequency (RF) output. The Alpha 8406 is capable of 1.5-kW continuous RF output with no time limit on any authorized amateur frequency in the range 50–54 MHz and on all commonly used modes, including the following:
  - — All digital modes
  - — Frequency modulation (FM)
  - — Keyed continuous wave (CW)
  - — Radioteletype (RTTY)
  - — Single sideband (SSB)
  - — Slow-scan television (SSTV)
- Compatibility with popular amateur transceivers and exciters. The Alpha 8406 requires ~50–65-W peak RF drive for 1.5-kW output.
- Capability of full CW break-in (QSK) when used with any appropriate transceiver.
- Built-in protective functions. The control system incorporates protective functions that minimize the probability of accidental damage to the amplifier or its tube. In most cases, when a protective function is tripped, the amplifier goes to standby mode.

1.3 Safety Considerations

General Considerations

For safe operation, take the following precautions:

- Locate the amplifier where there is good air circulation all around and on top of the cabinet. The unit may become hot during operation.
- Move the amplifier only with great caution, being sure to do the following:
  - — Remove the transformer and move it separately from the amplifier by means of its lifting handle. Never transport the amplifier with the transformer in place, as together they weigh ~70 pounds.
  - — Use proper lifting techniques and two people.
- Remember that, although the Alpha 8406 meets international safety standards and US Federal Communications Commission (FCC) regulations, it works with high voltages that can be LETHAL.

IMPORTANT

- **NEVER open the amplifier case without first unplugging the unit from the wall outlet.**
- **NEVER touch an antenna during transmission.**
- **NEVER turn on the amplifier without the cover securely in place and all attachment screws inserted.**
- **NEVER turn the amplifier back on after a hard fault (that is, a fault to power off) without waiting at least 20 seconds.**
- **NEVER cover or obscure the exhaust holes in the amplifier cover. Never stick objects into the holes or allow liquids to enter through the holes.**

RF Exposure

The FCC requires users to check their installations for compliance with published values for allowable exposure to RF fields. This information is available in American Radio Relay League (ARRL) publications, FCC printed rules, and on the web. We strongly recommend that you do this for any installation, either fixed and at an expedition or contest site.

SEE . . .

- For information on RF exposure, see *FCC OET Bulletin 65 Supplement B* at **http://www.fcc.gov/encyclopedia/oet-bulletins-line**.
- For questions regarding engineering your amplifier into your amateur radio station, go to **rfconcepts.com** and click **Support**.

1.4 Related Products

Other products available to enhance your use of the Alpha 8406 include:

- Alpha 2000 dummy load
- Alpha 4510A standing-wave-ratio (SWR) meters and wattmeters

For more information, go to **rfconcepts.com** or call **303-473-9232**.

1.5 Assistance

Technical assistance from RF Concepts is available from several sources.

- Go to our website at **rfconcepts.com** and click **Support**. On this site you can get the following assistance:
  - — Alpha Forum
  - — FAQs
  - — Legacy equipment information
  - — Manuals
  - — Repair information
  - — Software downloads
  - — Tech tips
  - — Technical support
- E-mail us by completing a support request at **rfconcepts.com**.
- Fax us at **303-473-9660**.
- Phone us at **303-473-9232**.

2 Amplifier Components and Specifications

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The Alpha 8406 uses a ceramic-and-metal forced-air-cooled tetrode vacuum tube for amplification. The main power supply is an unregulated transformer/rectifier/capacitor power supply for the high-voltage (HV) and heater circuits. All other power supplies are regulated.

The control circuit uses a microprocessor “in the loop” to monitor and control amplifier operation. There are eight circuit boards in the amplifier:

- Center-partition board
- Control board
- Display board
- HV board
- Low-pass filter board
- Mains board
- Transmit/receive (T/R) board
- Tube-deck board

In addition to these, the tube, tank circuit assembly, and transformer complete the main sections of the amplifier. These major blocks are described below.

The amplifier includes a 5-V power supply mounted behind the front panel. Whenever the amplifier is plugged into the mains power, this supply is active and there is power to the microcontroller on the main control board. This feature enables the amplifier to be turned on or off remotely. It also enables remote monitoring and debugging via a USB cable connected to a computer.

The amplifier front, back, and interior are shown below (see Figure 2-1, Figure 2-2, and Figure 2-3). Amplifier components are listed alphabetically and described below.

Figure 2-1 Amplifier front

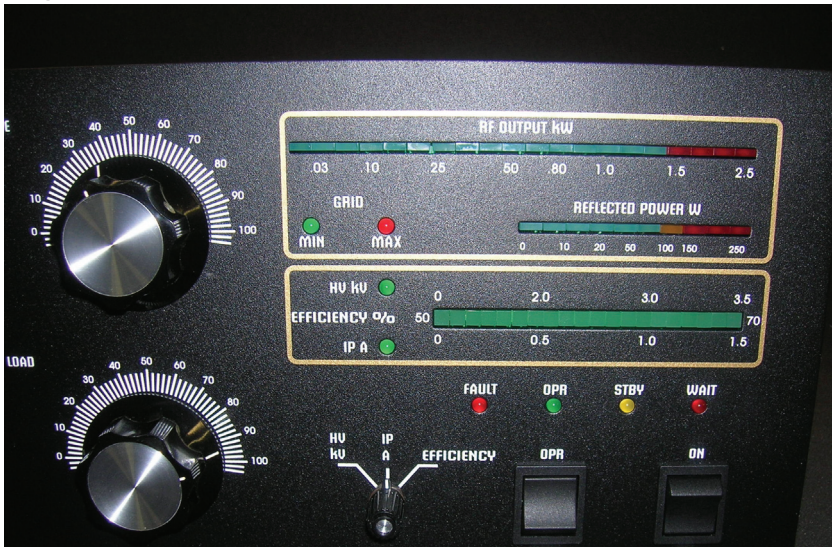
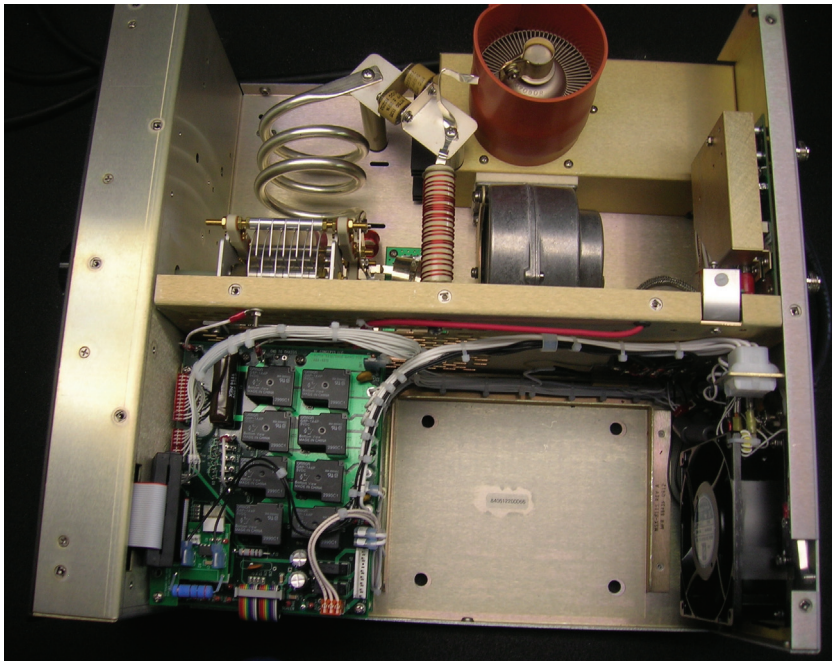


Figure 2-2 Amplifier back

Figure 2-3 Amplifier interior



2.1 Boards

The following amplifier boards are described below in alphabetical order:

- Center-partition board
- Control board
- Display board
- HV board
- Low-pass filter board
- Mains board
- Transmit/receive (T/R) board
- Tube-deck board

Center-Partition Board

The center-partition board contains the RF decoupling circuit on the B+ line as well as the crowbar safety circuit. When you remove the top cover of the amplifier, the spring metal of this safety device shorts out the B+ line.

IMPORTANT

Do not defeat this safety circuit. It is placed there for your protection.

Control Board

The control board is the heart of the amplifier. It is based on a PIC microcontroller. This microcontroller has a built-in multichannel analog-to-digital converter that monitors all critical voltages and currents in the amplifier as well as the input power and output forward and reflected power. It uses these converted values to control the amplifier's operation and to drive the display board on the front panel.

A USB port on the back of the amplifier is provided for remote monitoring. The USB driver for the amplifier is provided on the CD that ships with the amplifier or is available from the company website.

Display Board

The display board uses a MAX7219 multiboard LED-display-driver chip. The chip receives data from the control board via a serial peripheral interface (SPI); this data determines which LEDs to light. The board contains a regulator to drop voltage from +12 V to +5 V for the display.

HV Board

The main high voltage for the amplifier is created on the HV board using a full-wave bridge rectifier and a bank of capacitors. This power supply has two 10-ohm resistors, one in the positive (B+) lead and one in the negative return that goes to ground. This combination of resistors limits the surge current in the case of a B+ arc.

The voltage across the resistor in the negative return is used to monitor tube plate current in the control board. It is also used to generate a hard-fault condition. When the power-supply current exceeds ~2.5 A, a relay opens the coil circuit of the mains tap relays on the mains board, causing the amplifier to go to the power-off state. This hard-fault circuit operates independently of microprocessor control.

The regulated screen supply is also located on this board.

All power-supply filter capacitors on this board have bleeder resistors that discharge the capacitors in less than 60 seconds. If you must work on this board, confirm the discharged condition with a voltmeter, due to the remote possibility of bleeder resistor failure.

Low-Pass Filter Board

The output low-pass filter is a single-stage unit optimized for low loss at 6 m. The measured insertion loss is 0.14 dB. The inductor is made from wide silver-plated strap material. The capacitors are low-loss porcelain types. All joints are silver-soldered. Adequate cooling is ensured in two ways: the board has slots to enable cooling from both sides and it is mounted in front of the inlet to the blower to enable exposure to copious air flow.

Mains Board

Power-supply functions are split between the mains board and the HV board. The mains board deals mostly with the primary side of the transformer. The various taps for the transformer primary are routed through this board and so is the AC line input. Relays on the mains board connect the AC line to the appropriate taps on the transformer primary.

Also on the mains board is a step-start circuit. This circuit consists of a relay and a resistor, which are time-sequenced to limit the inrush current into the amplifier when it is first turned on. The regulated –12 and –124-V supplies are also located on this board. Many of the important voltages for the amplifier are brought to test points on this board.

The primary voltage taps are located on the top of the mains board, between the transformer and the front panel. There is a row of five “fast-on” connectors (J22 through J26) and a flying jumper connector that mates with them. The amplifier is always shipped with the jumper sent to J22 (the 240-V position).

T/R Board

The transmit/receive (T/R) board contains the input and output relays as well as the input-power detection and output directional wattmeter. Voltages from the detector are connected to the control board.

A trimmer capacitor on this board is adjusted at the factory. You should not touch it.

The board also has a safety inductor on the RF output for 50–54-MHz operation, located between the PCB and the rear chassis.

Tube-Deck Board

The tube-deck board is located in the tube deck, below the tube socket. It contains critical circuit elements that need to be in close proximity to the tube. The tube heater, bias, and screen connections are all located on this board. The tube-deck temperature sensor and the input match for the tube complete this board.

For more information on the tube deck, see Section 2.4, "Tube and Tube Deck," page 2–7.

2.2 Controls and Display

The Alpha 8406 controls enable you to adjust and monitor the amplifier as needed (see Table 2-1).

Table 2-1 Amplifier controls

Control	Purpose
LOAD	Controls the load capacitor. Sets the amplifier plate loading and determines the power level for best efficiency and linearity. Heavier loading is toward the 100 end and lighter loading is toward the 0 end of the dial scale.
TUNE	Controls the tune capacitor. Sets the output tank circuit to resonance at each frequency. Lower frequencies tend to tune toward the 0 end and higher frequencies toward the 100 end of the dial scale.

2.3 Output-Tank Circuit

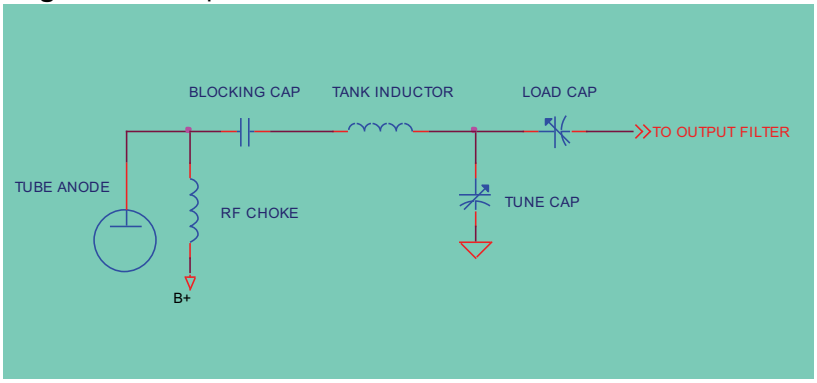
The output-tank circuit provides reliable high-efficiency, low-distortion performance in a very compact volume.

In any VHF amplifier, the most critical design decision is the output-tank network topology. We considered a transmission-line design but rejected it as being difficult and expensive to build. Likewise, we considered and

rejected the standard pi-L configuration that is used so widely at HF because of tough FCC harmonic requirements and the difficulty of achieving full output over the entire band.

The topology that we chose (see Figure 2-4) is the pi-C configuration, which provides harmonic attenuation adequate to meet the requirements of all countries globally that permit power outputs of 1500 W. In this configuration, the anode capacitance of the tube forms the input capacitance of the pi network. This network allows full coverage of the band with two rugged air-variable capacitors. A single large silver-plated inductor completes the tank arrangement; it is made from half-inch copper tubing that is formed to shape, then silver-plated. The single-tube design reduces tube capacitance and facilitates control of stray inductances in the circuit.

Figure 2-4 Output-tank circuit



2.4 Tube and Tube Deck

The Alpha 8406 uses a 4CX1500B tetrode vacuum tube. The tube is operated in Class AB1, with the following voltages:

- Plate voltage: 3500 V nominal
- Grid 1 voltage: –50 to –60 V
- Grid 2 voltage: +230 V

Electronic bias switching (EBS) increases the negative grid 1 voltage during pauses in speech or between Morse-code elements. This reduces the standing bias on the tube, resulting in less waste heat, longer tube life, and higher overall amplifier efficiency. The artifacts of EBS are not noticeable under normal communications conditions.

The tube is operated as a “swamped grid” tetrode design. The tube grid is tied at RF to a 50-ohm swamping resistor that absorbs most of the input-drive power. The RF voltage across this resistor is added to the grid 1 DC bias to provide the net low-impedance tube grid 1 bias. The RF

impedance represented by grid 1 and its capacitance are compensated for by a series inductance to provide SWR <2:1 across the full 6-m band at the amplifier's input.

The tube deck is a mechanical assembly enclosing the tube socket and the tube-deck board. The tube socket contains the integral screen grid (grid 2) RF bypass capacitors as well as contacts for the screen, heater, and filament of the tube.

The temperature sensor on the tube-deck board sends data to the amplifier's control board. This information is used to control the speed of the DC squirrel-cage blower that exhausts into the tube deck. Cool air is drawn into the amplifier by the muffin fan at the rear of the amplifier and over the transformer and the high-voltage section. The air then flows through the amplifier's center partition and is pulled in by the blower and forced through the tube fins to keep the tube within the correct operating-temperature range.

The blower has three speeds (low, medium, and high). The amplifier's control board determines which speed to set based on the temperature that is measured in the tube deck. Any time the amplifier is keyed and producing RF for more than 30 seconds continuously, the blower speed is set to medium speed. After 60 seconds, it is set to high speed.

NOTE

- The amplifier's grid-current-limiting circuits provide substantial protection against possible tube damage. Therefore, the amplifier does not generate or use Automatic Level Control (ALC) voltages to control an exciter. You need only set the input-drive power as explained in Section 4.5, "Set the Input-Drive Power," page 4–6.
- To prolong tube life, refrain from cycling AC power on-off-on-off repeatedly. It is less stressful to leave equipment on and in standby mode for several hours than to cycle it on and off repeatedly.

2.5 Specifications

The amplifier's specifications are as follows:

Table 2-2 Alpha 8406 linear amplifier specifications

Parameter	Value
Frequency coverage	50–54 MHz
Input-drive level	50 W nominal
Power output	1500 W
SWR tolerance	3:1
Duty cycle	100%
Tube	4CX1500B
Intermodulation level	34 dB two-tone (typical)
Harmonics	–72 dBc
Mode of operation	AM, CW, SSB, FM, RTTY, JT-65
Input AC voltage	100, 120, 200, 220, 240 selectable
AC current	<15 amps @ 240 VAC @1500 W
Input impedance	50 ohms
Output impedance	50 ohms
RF connectors	N female
Cooling	Forced air
Size	17.3"W × 7"H × 19.5"D including muffin fan
Weight	70 lb (31.8 kg)
T/R relay	Vacuum QSK
Tuning	Manual
Display	Bargraph LED
Interface	USB
Protection	Against all common faults
RF bypass level	<300 W

3 Preparing Your Station

3.1 Prepare Your Station 3–1
3.2 Understand the Limitations of Operation at Nonstandard Line Voltages 3–4

3.1 Prepare Your Station

The Alpha 8406 is capable of dramatically improving the performance of your amateur station. It is important that you observe good engineering practices to achieve all the benefits of such a station in a safe and reliable manner.

SEE . . .

In addition to reading this chapter, we recommend that you consult a good source of general information such as the latest *Amateur Radio Relay League (ARRL) Handbook for Radio Amateurs*, especially if this is your first high-power amplifier.

Procedure 3-1 Prepare your station

Step 1 Provide 220-VAC power.

1a If you do not have a 220-VAC outlet in your station, have a licensed electrical contractor install one. The amplifier runs best when powered by a 200–240-VAC circuit. A minimum of a 20 A capacity is required. A 20-A breaker on your 220-V circuit is sufficient.

IMPORTANT: Although the amplifier can run when connected to a 120-VAC outlet, it will give you <1000-W output, much lower than the full legal limit.

For information on the use of nonstandard line voltages, see Section 3.2, "Understand the Limitations of Operation at Nonstandard Line Voltages," page 3–4.

1b When sizing the circuit, be sure to include the current drawn by other equipment that may be on the same circuit.

1c Select a location for the outlet as close as possible to where you expect to operate the amplifier. If you are not sure or contemplate moving the amplifier, consider installing two outlets.

1d Ask your contractor for two or three matching plugs during installation. There are many styles of power plugs, some of which are country-specific. A NEMA 6-20 plug is installed at the factory.

1e Ask your contractor to measure the voltage and record it for reference. If possible, have the contractor measure the line voltage with a 10-A current draw, and use this value for setting the transformer tap.

Step 2 Provide proper airflow:

2a Maintain at least 3 inches of clearance around the amplifier and at least 4 inches of clearance around the air intake and exhaust areas to allow for unobstructed airflow at all times. Ensure that exhausted air cannot recirculate back into the amplifier air intake. We recommend that you do not stack equipment on top of the amplifier.

2b If you are mounting the amplifier in a console, ensure that the exhaust air is properly and fully removed from the console. If outlet air is drawn back into the amplifier air intake and recirculated, the amplifier gets hotter and hotter, resulting in degraded performance or even failure. If you are designing your own console, consider putting in additional fans and/or ducting to deal with waste heat.

2c Ensure that equipment or other objects are not stacked on top of the amplifier.

2d Minimize the possibility of dust or other contamination getting drawn into or falling on the amplifier. Plan to periodically (at least annually) clean the dust out of the amplifier, paying particular attention to the tube fins. For more information, see Section 6.1, “Clean the Amplifier Chassis,” page 6–1.

Step 3 Ready the antenna:

3a Ensure that the antenna is rated for 1500 W and that it is carefully tuned and installed for minimum voltage SWR.

Many antennas that are suitable for general use are unsuited for operation at full 1500-W power. At this power level in a 50-ohm circuit, the RMS current is 5.5 A and the peak RF voltage is 387 V. For SWR = 2:1, these values double to 11 A and 775 V. The actual voltage and current at various points in or on your antenna may be many times these values.

3b If an antenna has been deployed for a long period of time, take it down and inspect it before full-power operation.

Step 4 Provide adequate RF cabling.

IMPORTANT: The importance of a well-constructed feed-line system cannot be overstated.

The purpose of the amplifier is to provide approximately 2 S units (≥12 dB) of improvement in your radiated signal. Cheap, poor, or underrated cables and connectors can degrade performance by at least one S unit. (This means that you could have bought a 375-W amplifier and achieved the same radiated signal by buying good-quality feed-line components!) Never use old coax, which may have had moisture penetrate under the jacket.

4a Use good-quality low-loss coaxial cable.

4b Ensure that the cables have a solid ground shield in place.

⚠ CAUTION

CAUTION! When using any high-power amplifier, failure to connect ALL station equipment to a good common ground may allow RF feedback to leak into the transceiver and cause severe signal distortion.

4c Use new, clean connectors and install them according to manufacturer recommendations. After soldering the connectors and before mating them with the amplifier, clean the connectors. Remove any excess solder, braid fragments, and the like.

4d Support the coax frequently using noncompressive clips so that it does not hang or stretch under its own weight. Avoid sharp or kinked bends (most manufacturers specify a minimum bend radius for their product).

4e Ensure that the connection from feed line to antenna is waterproof.

4f Provide for disconnection of the feed line when it is not in use. This protects against damage caused by static charges and lightning strikes.

IMPORTANT: Damage from static charges and lightning strikes is not covered under warranty.

NOTE: The FCC requires users to check their installations for compliance with published values for allowable exposure to RF fields. This information is available in ARRL publications, FCC printed rules, and on the web. We strongly recommend that you do this for any installation, both fixed and at an expedition or contest site.

- For information on RF exposure, see Section 1.3, "Safety Considerations," page 1–3.
- For questions regarding engineering your amplifier into your amateur radio station, go to **rfconcepts.com** and click **Contact Us**.

Step 5 Provide surge protection.

IMPORTANT: Induced energy from nearby electrical storms or other power transients may damage amplifier components.

Such damage is not covered under warranty. It is therefore important to use a good lightning arrestor. However the only lightning-proof solution available is to disconnect antenna feedlines and AC power when the equipment is not in use.

Whenever the amplifier is online — either off, in STBY mode, or warming up with the WAIT LED lighted — the amplifier is bypassed and the exciter is connected directly to the antenna.

- For SWR = 1:1, the throughput limit in all cases is 300 W.
- For SWR > 1:1, reduce the power level as necessary. Any reflected power level higher than 100 W may damage the RF switching relays in the amplifier.

3.2 Understand the Limitations of Operation at Nonstandard Line Voltages

Electrical-power equipment draws twice as much primary current from a 120-V mains as from a 240-V mains. Therefore, if you operate the amplifier on typical 120-V/20-A household circuit without exceeding the 20-A circuit rating, you limit maximum peak power output to ~600–1000 W.

The maximum possible RF output power for any particular primary AC voltage and current capacity is

$P_{0\,\max} \approx (V \times I) / 2.3$

For example, if the amplifier operates from a circuit that is capable of delivering 120 V AC at a maximum current of 20 A with no other loads connected to the circuit, the maximum peak RF output possible without tripping the 20-A breaker/fuse is

$P_{0\ max} \approx (120\ V \times 20\ A) / 2.3 = 1043\ W$

If the same circuit also supplies a transceiver drawing peak line current of 5 A and a lamp drawing 1 A, only 20 – 5 – 1 = 14 A is available for the amplifier, reducing the maximum possible power to $P_{0\ max} \approx 730$ W.

For expected behaviors at nonstandard line voltages, see Table 3-1.

Table 3-1 Amplifier behavior at nonstandard line voltages

Line voltage	Expected behavior
Low: 90–130 V	For a line voltage of <120 V, do not expect to get 1500-W output. For maximum efficiency, tune the amplifier for no more than 1000-W output. For a line voltage of 110–130 V, 1500-W peak-envelope-power (PEP) operation (CW or SSB) may be possible if your AC line service has sufficient current capacity (30-A circuit recommended). However, do not expect to get continuous 1500-W output.
High: >250 V	Tube lifetime may be reduced. Try the following: • Ask your utility company to reduce your line voltage. • Place your own step-down transformer in line between the AC outlet and the amplifier. A transformer with at least 4-kVA rating is required, due to the nature of the current waveform in the primary. • Use a ferroresonant voltage regulator. This is an expensive but effective way to stabilize primary voltage.

IMPORTANT

If you intend to operate the amplifier at 90–130 V or if other equipment draws current from the same circuit as the amplifier, do the following:

1. Ensure that the AC cord is not coiled too tightly or placed where normal air flow is restricted and can cause it to overheat.
2. Change the bottom 2-A slow-blow fuse on the rear panel to a 5-A slow-blow fuse to allow for the increased in-rush current.

4 Setting Up the Amplifier

4.1 Unpack the Amplifier and Transformer 4–1
4.2 Connect the Transformer 4–2
4.3 Adjust the Tube and Exhaust Chimney 4–3
4.4 Connect the Cables 4–3
4.5 Set the Input-Drive Power 4–6

IMPORTANT

- The Alpha 8406 is extremely easy to set up, operate, and maintain. However, failure to carry out each procedure exactly as described in this manual is likely to lead to amplifier damage. **Such damage is not covered under warranty.** Damage to other station equipment may also result.
- Proceed slowly throughout these procedures to avoid bumping and damaging adjacent wires, connectors, and components.

4.1 Unpack the Amplifier and Transformer

Procedure 4-1 Unpack the amplifier and transformer

Step 1 Prepare your station as described in Chapter 3, "Preparing Your Station."

Step 2 Remove the amplifier and transformer from their cartons.

The Alpha 8406 ships in two heavy-duty double-wall cardboard boxes. The carton containing the amplifier weighs 50 lb (23 kg); the carton containing the transformer weighs 43 lb (20 kg).

2a Inspect the boxes for shipping damage.

2b Unpack the boxes and place the contents on a workbench or table.

2c Retain the boxes and all packing material in case you need to ship the unit later.

Step 3 Inspect the amplifier and transformer for shipping damage.

If you find damage, contact RF Concepts technical support.

4.2 Connect the Transformer

IMPORTANT

- The transformer is very heavy. When moving it, use due caution and handle it only by the lifting handle.
- Do not over-tighten the screws that hold the transformer in place, as doing so may cause excessive vibrations or noise.
- If you move the amplifier, even if only from one site to another locally, remove the transformer first to avoid the possibility of damage.

Procedure 4-2 Connect the transformer

Step 1 Remove the amplifier cover and set it aside.

The cover is attached with 31 6-32 screws, 10 on each side of the amplifier and 11 on the top.

Step 2 Position the amplifier on a flat surface, at or near where it is to be used, with plenty of room for you to work.

The amplifier chassis is designed for the mechanical loads experienced when the amplifier is on a flat surface with the tilt bail up or down. Installing the amplifier on a tilt so far that the transformer is cantilevered or hangs out to any degree can cause the chassis to distort.

Step 3 Pick the transformer up by the handle and move it onto the lip at the edge of the chassis, about half way into the amplifier.

Step 4 Connect the transformer:

4a Connect the transformer's 9-pin white Molex connector to the matching 3x3 Molex connector on the back of the amplifier's back wall. Use the handle to move the transformer all the way into the amplifier and push it toward the center.

4b Connect the transformer's 8-pin orange connector to the matching pins on the amplifier's mains board (the upper of the two boards).

4c Connect the transformer's 6-pin yellow connector to the matching pins on the amplifier's HV board (the lower of the two boards), routing it to the left of the white post between the boards.

4d Ensure that all connector pins on these three connectors engage fully and correctly.

Step 5 Secure the transformer into place from the bottom of the amplifier by inserting the supplied bolts (1/4/20 ½-inch hex bolts) with ¼-inch washers through the four clearance holes in the chassis and into the nuts in the transformer base.

⚠ CAUTION

CAUTION! Do not use the transformer's shipping bolts. They are too long and will damage the transformer!

4.3 Adjust the Tube and Exhaust Chimney

With the amplifier cover removed, adjust the tube and exhaust chimney.

Procedure 4-3 Adjust the tube and exhaust chimney

Step 1 Ensure that the tube is firmly seated in its socket.

The 4CX1500B tube has a bayonet-style base. It is installed onto a central pin in the tube socket and then rotated clockwise into place so that the flanges on the tube line up with the connectors in the socket. To remove the tube, rotate it counter-clockwise and then pull it up out of the socket.

Step 2 Ensure that the anode connector is tightly clamped to the tube.

Step 3 Ensure that the silicon-rubber exhaust chimney is straight and that the bottom is firmly against the tube deck and completely covers the airflow opening in the deck.

The chimney should be flush with the top cover when it is placed back on the amplifier. Tube-cooling exhaust must exit only through the tube anode fins; it must not be allowed to escape outside them.

IMPORTANT: Damage caused by insufficient cooling airflow is not covered under warranty.

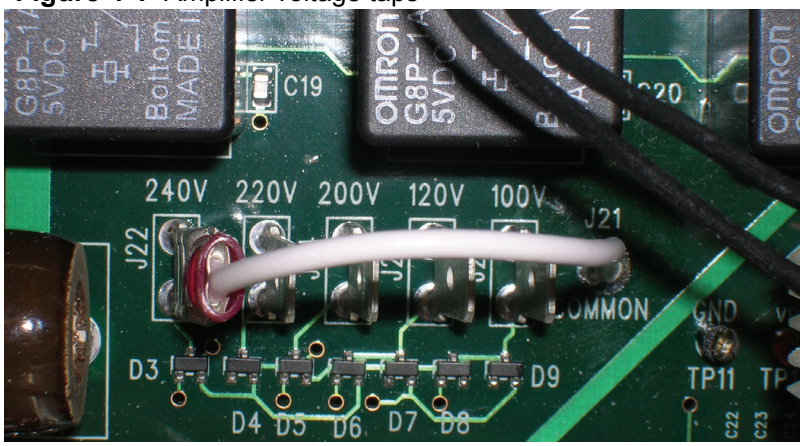
4.4 Connect the Cables

Procedure 4-4 Connect the cables

Step 1 Set the voltage tap.

A row of primary voltage taps is located on the top of the mains board, between the transformer and the front panel. The row contains five fast-on terminals (J22 to J26) and a flying jumper connector that mates with them (see Figure 4-1).

Figure 4-1 Amplifier voltage taps



1a Ensure that the amplifier is unplugged.

1b Connect the flying jumper connector to the terminal marked with the appropriate voltage.

These five nominal primary voltages — 100, 120, 200, 220, and 240 V — cover all the line voltages normally encountered around the world. The nominal midrange voltage for each tap is printed on the mains-board circuit board. The acceptable line voltage for each tap is the center voltage plus or minus 10 V.

Important: To prevent damage to the tube and amplifier, never set a tap to other than the proper voltage. We strongly recommend that you operate the amplifier on 240 VAC. If you choose to do otherwise, see Section 3.2, "Understand the Limitations of Operation at Nonstandard Line Voltages," page 3–4.

Step 2 Connect the power cord.

WARNING

WARNING! To avoid the hazard of a potentially fatal electric shock and/or severe damage to the amplifier and other equipment:

- **NEVER operate the amplifier with the cover removed.**
- **ALWAYS use an AC plug that is appropriate for the amplifier's primary mains voltage, current rating, and configuration.**
- **ALWAYS use grounding-type AC connectors that conform to local codes.**
- **NEVER use 120-VAC plugs and power receptacles for 190–250-V circuits.**
- **ALWAYS connect ALL station equipment to a good common ground. Failure to do so may allow RF feedback to leak into the transceiver and cause severe signal distortion.**

2a Connect the green wire in the amplifier power cord only to the AC mains safety ground (or to neutral, as may be necessary with a 240-V circuit configured 120V-N-120V without a separate ground, commonly found in the US).

2b Connect the black-and-white wires in the amplifier power cord to the two hot wires of the AC source. Either wire may be connected to either side of the line. For best results, use a dedicated 200–240-V branch circuit of #10 AWG copper wire or equivalent, rated at 20 A, to feed the amplifier.

Step 3 Replace the amplifier cover and all attachment screws.

Use only the 6-32 screws supplied with the amplifier. Do not tighten any of the screws until all are started.

⚠ WARNING

WARNING! Do not attempt to operate the amplifier with the cover removed or placed on the unit without the attachment screws. Doing so damages the amplifier and may also cause injury or death to the operator.

Step 4 Place the amplifier in its operating position on a stable surface with sufficient space to the rear, sides, and top to allow good air flow and safe placement of cables.

It is important to maintain at least 3 inches of clear space above the amplifier for the warm exhaust air from the tube and to ensure that this warm air is not drawn into the back of the amplifier again.

Step 5 Connect the amplifier's RF INPUT to the transceiver's RF OUTPUT.

Use 50-ohm coaxial cable RG-58C/U or equivalent.

Step 6 Connect the amplifier's RF OUTPUT to the antenna.

Use RG-213/U, LMR-400, or LMR-600 cable.

Step 7 Connect the transceiver's control (T/R) cable to the amplifier's KEY IN input.

The amplifier's relay jack has ~12 V on it. When pulled all the way to ground, a current of 10 mA flows. For information on how to connect to an external amplifier, see your transceiver manual.

The amplifier has a full break-in vacuum relay QSK system that requires only the normal interconnection when used with a modern QSK transceiver. The amplifier requires a contact closure (short circuit) on

transmit on the amplifier's RELAY jack center pin to the chassis. This function is supplied by the transceiver, usually from a dedicated relay that is normally open in RECEIVE mode and closed in TRANSMIT mode.

7a Use shielded wire for the T/R control cable. Fit the amplifier end with a common phono (RCA-type) plug and the transceiver end with a suitable connector.

7b Ensure that the T/R relay contact closes. Modern transceivers have the proper time delay between key-up and the start of the transmitted signal to allow the amplifier to follow the CW keying.

4.5 Set the Input-Drive Power

The amplifier's grid-current-limiting circuits provide substantial protection against possible tube damage. Therefore, the amplifier does not generate or use Automatic Level Control (ALC) voltages to control an exciter. You need only set the input-drive power as described in this section.

IMPORTANT

- The amplifier requires up to 50-W drive for full rated output.
- You must set the transceiver output power properly. It is not sufficient to set only the transceiver POWER or RF PWR control. Virtually all damage to date has resulted directly from severe overdrive.
- Several popular transceivers can generate RF spikes of 200–300 W. Adjust your transceiver so that it does not produce over-wattage spikes. For more information, see the manual for your particular transceiver.
- **Damage caused by application to the amplifier of several-times-rated drive power is not covered under warranty.** Fortunately, most modern transceivers maintain quite consistent output from band to band and mode to mode when set up properly.

Procedure 4-5 Set the input-drive power

Step 1 Consult your amplifier's specific performance data sheet to determine the drive requirements and the tune and load settings required to deliver 1500 W.

This data sheet is placed inside the amplifier (in the space where the transformer goes) at the factory before shipping.

Step 2 Set the transceiver's power output so as not to overdrive the amplifier input. For information on how to do so, see the manual for your particular transceiver.

Step 3 If the transceiver is more than 15 years old, reduce the power output so that voice peaks do not overdrive the transmitter under any modulation condition.

5 Operating the Amplifier

5.1 Start Up the Amplifier 5–1
5.2 Tune the Amplifier 5–2
5.3 Operate the Amplifier 5–5
5.4 (Optional) Operate the Amplifier Remotely 5–6

IMPORTANT

- The Alpha 8406 is extremely easy to set up, operate, and maintain. However, failure to carry out each procedure exactly as described in this manual is likely to lead to amplifier damage. **Such damage is not covered under warranty.** Damage to other station equipment may also result.
- **If the amplifier faults during operation, do not turn it off.**

  To clear a fault:

  — For a gain fault, wait for the amplifier to reset itself.

  — For all other faults, resolve the fault as described in Chapter 7, "Diagnosing Faults and Troubleshooting." Then put the amplifier back into operation.

5.1 Start Up the Amplifier

Procedure 5-1 Start up the amplifier

Step 1 Set up the amplifier as described in Chapter 4, "Setting Up the Amplifier."

Step 2 Set the multimeter selector switch to **HV**.

Step 3 Press the **POWER/ON** switch.

The following occur:

- The fan and internal blower begin to operate. Within 5 seconds, the blower increases to high speed and then drops back to idling speed. If there is no air flow from the amplifier and no sound of blower operation, immediately turn the amplifier off and investigate.
- Within 2 seconds, the HV display moves all the way to the right, certainly to >3000 V. If it is lower than this, investigate further; the primary taps may not be correctly set.

- The red LED representing 1800-W output power lights up, indicating the start of a built-in180-second countdown (1800/10 = 180 seconds). As the timer counts down, the remaining time is indicated by the currently lit LED on the power-output bargraph.

Step 4 Set the multimeter selector switch to **Ip** (plate current) and leave it there while the warmup countdown proceeds.

No current should be indicated during the entire warmup period. The WAIT and STBY LEDs blink about twice per second, indicating that warmup is still in progress. The FAULT and OPER LEDs remain unlit.

Step 5 Ensure that exhaust air is detectable from the exit vent holes above the tube.

If exhaust air is NOT detectable, TURN OFF the amplifier immediately, ensure that the exhaust chimney is properly positioned over the tube, and power up the amplifier again.

Step 6 When the WAIT LED goes out and the OPR or STBY lights stop blinking, indicating that warmup is complete, move the **OPR/STBY** switch to **OPR**.

5.2 Tune the Amplifier

Each amplifier ships from the factory with a performance data sheet showing the tune and load settings that we used to achieve full output power on that particular amplifier into an Alpha 2000 50-ohm dummy load. You can find this data sheet inside the amplifier in the space where the transformer normally goes.

Your goal in tuning the amplifier is to optimize efficiency and linearity at a specific output power. Operation at higher or lower power results in the following:

- Operation at higher power without appropriate readjustment results in flat-topping, also known as “splatter,” and (usually) excessive amplifier grid current.
- Operation at lower power results in decreased amplifier efficiency.

Recommended Practice

We recommend that you tune first into a dummy load or artificial antenna, then connect the antenna and make any slight final adjustments that may be needed.

High-SWR Considerations

For any frequency where antenna VSWR > 1.5:1, it is important to retune the amplifier for a proper match. The Alpha 8406 does not contain an antenna tuner. The SWR can be tuned via the antenna or an external tuner connected to the amplifier output. Nevertheless, at SWR < 2:1, the additional RF power loss of an antenna tuner can be avoided by tuning the amplifier into the slight mismatch. There is no advantage to using a tuner to tweak the last bit of SWR; in fact, you lose power this way.

RF and Mistuning Protection

The amplifier senses the beginning of any RF arc in, for example, a TUNE or LOAD variable capacitor and automatically switches the amplifier to standby mode within a few milliseconds. This system has virtually eliminated RF arc damage in current Alpha amplifiers. The system similarly detects severe mistuning and, if drive exceeds ~20 W, switches the amplifier to standby mode. The 20-W input trip threshold permits safe tuning at low power levels without aggravating and unnecessary trip-outs.

Retuning

If you tune the amplifier for maximum power output and then decide to operate it at a power output much different from 1.5 kW, you must retune it for clean and efficient operation.

⚠ CAUTION

CAUTION! During tuning, if the amplifier fails to respond as described, do the following:

1. Remove drive immediately.
2. Turn the **OPR/STBY** switch to **STBY**.
3. Verify all connections and cables.
4. Turn the amplifier switch to **OPR**.
5. Proceed with the tuning procedure.

Following is our recommended procedure for tuning the amplifier. When the amplifier is tuned properly on 6 meters, you should see the parameters listed in Table 5-1.

Table 5-1 Parameters indicating proper tuning

Parameter	Value
Ip	In the range 0.9–1.1 A (read on the 0–1.5-A scale) for 1500-W output.
Input drive	At or below ~50 W.
Power output	Full legal, depending on voltage SWR: • For SWR < 2.0:1, 1500 W (with 40–50 W drive) • For SWR > 2.0:1, full power may not be possible but the other tuning indications are the same
Grid current	Green light flickers barely if at all (normally 40 mA). At >100 mA, the system alarms.
Efficiency	Approximately 60%. During normal operation, this is the most useful parameter to monitor on the multimeter bargraph. The range of the efficiency scale on the amplifier's front panel is from 50% to 70%. As the amplifier's output power level decreases, efficiency also decreases; below about 1 kW, it falls to <50%, at which point the efficiency display is not usable. However, efficiency is still calculated on the control board and the data are available via the USB port.
Plate current	In the green zone (1 A at 1500 W). At >1.6 A, the system alarms.

Procedure 5-2 Tune the amplifier

Step 1 Start up the amplifier as described in "Start Up the Amplifier," page 5–1.

Step 2 Set the TUNE and LOAD controls to the values given in your amplifier's specific performance data sheet.

Note that final TUNE and LOAD settings will vary with operating frequency, antenna characteristics, and power level.

Step 3 Limit the transceiver drive to <50 W for tuning and operating the amplifier.

Step 4 Set the multimeter selector switch to **Ip** (plate current).

Step 5 Key the amplifier with 10-W drive and adjust the TUNE control so that the peak in RF out is at the same point as the dip in Ip.

Step 6 Increase the amplifier's drive to 500-W output, going back and forth between TUNE and LOAD to peak the RF output.

To increase output, increase the drive slightly, increase LOAD for a peak in RF out, then peak RF out with TUNE control.

Step 7 Further increase the amplifier's drive to the desired power level and adjust settings to maximize amplifier efficiency:

7a Set the multimeter selector switch to **Efficiency** and set the radio to RTTY or CW to transmit a steady carrier.

7b Set the tune and load controls to the settings listed on the amplifier's performance data sheet as required to achieve 1500 W output in the lab, key the amplifier with RF, and adjust the tune and load controls for maximum efficiency (the efficiency scale range is 50% to 70%).

7c Increase the drive power to the desired output power, then readjust the tune and load controls for maximum efficiency.

After 30 seconds of keydown, the internal blower is set automatically to medium speed.

5.3 Operate the Amplifier

NOTE

If the amplifier faults during operation, it usually resets itself after 4 seconds. For information about faults, see Chapter 7, "Diagnosing Faults and Troubleshooting."

Procedure 5-3 Operate the amplifier

Step 1 Start up and tune the amplifier as described in "Start Up the Amplifier," page 5–1 and "Tune the Amplifier," page 5–2.

Step 2 Apply RF.

The amplifier requires only ~50 W for full output.

Note that applying RF can cause the internal blower to change speed. Any time the amplifier is keyed and producing RF for more than 30 seconds continuously, blower speed is set to medium; after 60 seconds, it is set to high.

Step 3 When operating primarily in CW or SSB mode, monitor plate current.

- Idling plate current for the Alpha 8406 is ~350–400 mA during full-power transmission. A detector senses RF drive, and, during pauses in speech and key-up intervals, reduces plate current to 30–50 mA, substantially reducing average power supply loading, heat generation, and wasted energy.
- Do not allow key-down plate current to exceed 1.5 A for more than a second or two. If you do and the overcurrent plate current trip occurs, after you return the amplifier to RECEIVE mode (key up), it automatically resets in ~4 seconds.
- If the plate current becomes excessive or the high-voltage circuitry faults, the plate-current relay quickly turns the amplifier off. However, the relay does not prevent tube or other damage due to either short-term or long-term overdrive or improper tuning. It is your responsibility to ensure safe tuning, drive, and general operating conditions.
- If the overcurrent relay trips, remove AC power from the amplifier, then determine and correct the cause of the trip before turning the amplifier back on. This hard-fault trip circuit does not rely on the microcontroller for its operation, and protects the amplifier even if the processor is damaged or malfunctioning.

Step 4 When operating in JT-65 or another keydown mode, monitor the efficiency display and use the tune and load controls as required to keep efficiency maximized.

Step 5 Monitor grid current.

The green grid light normally flickers occasionally in any operating mode as RF is produced. Whether you see this depends on your particular tube, amplifier, and current mode of operation. You should not expect to see the green light come on full during normal operation.

The red grid light indicates excessive grid current resulting from overdrive and/or inadequate loading. Address this problem as soon as possible by reducing the drive and/or increasing the load control.

5.4 (Optional) Operate the Amplifier Remotely

You can operate the Alpha 8406 remotely, and therefore presumably unattended. Such remote/unattended operation is possible because tuning on the Alpha 8406 is broad, so there is often no need to readjust it once correct tuning has been established.

Remote/unintended operation is advantageous in that it can enable you to put the amplifier close to the antenna, an important consideration on VHF.

NOTE

Although you can operate the amplifier remotely, you cannot adjust the tune and load controls via the USB interface remotely. Nor do we at RF Concepts make our own software available to you for this purpose.|However, an excellent control program is available from Dan Greil (AE9K) on his website at **www.ae9k.com**.

There are three ways to operate the amplifier remotely:

1. Via direct USB connection from a PC at the operating position using one or more USB cables and hubs. The length of a single USB hop is limited to 5 m (about 16 ft). You can extend this length by using USB hubs.
2. Via a dedicated PC remote to the operator and adjacent to the amplifier, connected to the amplifier by a single USB cable. The remote-control program runs on the PC, and you connect to it using remote-desktop software such as Remote Desktop, LoMein, or GoToMyPC.
3. Via a PC or other computer (example: Linux on a Raspberry Pi board) adjacent to the operator and remote from the amplifier, connected to the amplifier by some form of serial-port redirection such as serial-over-IP to create a virtual COM port on the PC.

   This is the trickiest to set up, and requires that you have a good knowledge of computers and networking. We offer no support for this, since setup requires intimate knowledge of the details of your network. Other users on the RF Concepts forums may be able to help.

Other ways may be possible as well, such as via wifi-to-serial or Ethernet-to-serial converters. Such implementations are the responsibility of the user.

6 Maintaining the Amplifier

6.1 Clean the Amplifier Chassis 6–1
6.2 Replace the Tube and/or Fuses 6–2

IMPORTANT

- The Alpha 8406 is extremely easy to set up, operate, and maintain. However, failure to carry out each procedure exactly as described in this manual is likely to lead to amplifier damage, which is not covered under warranty. Damage to other station equipment may also result.
- Do not apply oil or grease to any amplifier components. There are no user-accessible lubrication points in the amplifier.
- The amplifier is equipped with a cover interlock switch that removes primary power from the amplifier and a crowbar that short-circuits high voltage to the chassis when the cover is lifted. These interlocks protect against electric shock resulting from accidental contact with the lethal voltages inside the amplifier.

  The cover interlock is intended only as backup protection against accidents. Never depend on it! Always disconnect the power cord from the AC mains before removing the cover.

  IMPORTANT: Do not disable the interlock switch for any reason.

6.1 Clean the Amplifier Chassis

Perform this procedure at least once a year.

Procedure 6-1 Clean the amplifier chassis

Step 1 Power down the amplifier.

Step 2 Clean the exterior with a mild liquid detergent. Do not use chemical solvents, as these may severely damage the front panel or cabinet finish. Never use an abrasive cleaner.

⚠ WARNING

WARNING! Do not allow any liquids to enter the cover's tube-exhaust holes.

Step 3 Disconnect the AC line cord from the power source and remove the cover.

⚠ WARNING

WARNING! Before lifting the cover for any reason, disconnect the AC line cord from the power source.

Step 4 Clean the interior, particularly high-voltage areas, with a vacuum cleaner and a soft bristle brush frequently enough to prevent visible accumulation of dust. Optimally, remove the plate under the tube deck (attached with 4 screws) and use compressed air to blow out the cooling fins in the tube.

Step 5 If conditions are extremely dusty, secure a thin air filter of the type used for window air conditioners across the air intake on the rear panel.

Step 6 Replace the cover and reconnect the AC line cord to the power source.

6.2 Replace the Tube and/or Fuses

Perform this procedure only as needed.

Procedure 6-2 Replace the tube and/or fuses

Step 1 Power down the amplifier.

Step 2 Disconnect the AC line cord from the power source and remove the cover.

⚠ WARNING

WARNING! Disconnect the AC line cord from the power source before lifting the cover for any reason.

Step 3 Replace the tube as needed. Ensure that cooling airflow to the tube is sufficient.

Use a high-quality 4CX1500B tube.

Step 4 Replace fuses as needed.

For 190–210-VAC service, use only 20-A, 250-V-rated fuses. For 90–130-VAC service, you may optionally use 25-A fuses with caution.

IMPORTANT: Never replace a fuse with one of a different type or greater current rating. Damage resulting from

use of a fuse of incorrect size or type is not covered under and may void the warranty.

Blowing of one or both primary-line fuses indicates that the maximum safe average power capability of the amplifier has been substantially exceeded or that an equipment failure has occurred.

Step 5 Replace the cover and reconnect the AC line cord to the power source.

7 Diagnosing Faults and Troubleshooting

7.1 Diagnose Faults 7–1
7.2 Troubleshoot Problems 7–4

7.1 Diagnose Faults

If the amplifier encounters unsafe operating conditions, it enters a protective fault mode and faults into STBY or OFF. The OPR LED goes off and the FAULT and STBY LEDs go on.

When this happens, the tube is biased off and the relays are placed in bypass mode, causing RF from the radio to go directly to the antenna. The FAULT LED on the front panel flashes on and off for ~4 seconds. After this period, unless the OPER/STBY switch has been placed in the STBY position, the amplifier attempts to return to OPERATE mode. You can shorten this 4-s period by toggling the OPER/STBY switch.

While the FAULT LED is flashing, the Ip and HV LEDs indicate which fault type caused the amplifier to enter fault mode. Fault-type codes are also reported in the amplifier telemetry data via the USB port on the rear of the amplifier. These fault types are summarized in Table 7-1 and described in the following text.

Table 7-1 Fault types

Fault type	LED behavior		Cause
	Ip LED	HV LED	
1	Blinking	Blinking	Amplifier gain is below 10 dB.
2		Dark	Plate current in the tube exceeds 1.6 A.
3	Dark	Blinking	Reflected power is too high.
4		Dark	Input-drive power is too high.
5*			Plate current exceeds 2.5 A.
6*			Plate current was detected during warmup.

* Faults 5 and 6 do not display on the front panel. Rather, they indicate only through telemetry via the USB port.

Fault type 1

LED behavior Both Ip and HV LEDs are blinking.

Cause Amplifier gain has fallen to <10 dB.

This is an important safety feature of the amplifier, as many different problems can be detected as a drop in gain. So that this fault does not occur while the amplifier is being tuned, gain fault detection is disabled when drive power to the amplifier is below ~20 W. This allows correct initial amplifier tuning to be achieved before going to full power.

Resolution

1. Reduce the input-drive power.
2. Retune the amplifier.

Fault type 2

LED behavior Ip LED is blinking.

Cause Plate current in the tube has exceeded 1.6 A. If the current exceeds ~2.5 A, AC select relays are de-energized and the amplifier shuts off completely.

Resolution

1. Retune the amplifier.
2. Ensure that the amplifier is not overdriven.
3. Fix any problems in the bias-control circuitry.
4. If the amplifier has shut off, wait at least 20 seconds, then use the **ON/OFF** switch to turn the amplifier back on.
5. If the amplifier trips again immediately, investigate and resolve the problem before attempting to turn the amplifier on again.

   DO NOT repeatedly hit the ON switch when the amplifier trips out. Doing so is likely to result in severe damage to amplifier components.

   When you are certain that you have taken care of the problem that caused the fault, you may turn the amplifier back on.

Fault type 3

LED behavior HV LED is blinking.

Cause Reflected power is too high.

The amplifier trips when reflected power exceeds ~250 W. At 1500-W output, this represents a voltage standing-wave ratio (VSWR) fault exceeding 3:1.

Resolution

1. Check the output coaxial cable and connectors; replace or reconnect as needed.
2. Check the antenna SWR using an external wattmeter or by putting the amplifier in standby mode and using the SWR meter on your transceiver. Make adjustments as needed.

Fault type 4

LED behavior Neither Ip nor HV LED is blinking; both are dark.

Cause Input-drive power is too high.

The amplifier behaves as follows at various input-drive power levels:

- When power is below 75 W, the amplifier operates normally.
- When power spikes above 75 W, a 500-ms timer starts, during which time the power threshold is reduced from 75 to 65 W. If you do not reduce the power to below the threshold at the end of 500 ms, Fault 4 results.
- When power exceeds 100 W (the absolute maximum value at which the amplifier can operate), an immediate Fault 4 results.

Resolution Decrease the input-drive power.

Fault type 5

LED behavior The amplifier shuts off and goes to State 0.

Cause A hard fault has occurred because input-drive power exceeded 125 W, causing plate current to exceed 2.5 A (Ip > 2.5 A).

Resolution Decrease the input-drive power.

Fault type 6

LED behavior The amplifier shuts off and goes to State 0.

Cause A hard fault has occurred because significant plate current was detected when the amplifier was warming up or was unkeyed (States 1–3). The threshold for this fault is one-third of the value for a "soft" Ip trip, or 533 mA.

Resolution

1. After the amplifier shuts off, wait at least 20 seconds, then use the **ON/OFF** switch to turn the amplifier back on.

   IMPORTANT: When the amplifier trips out, DO NOT repeatedly press the ON/OFF switch to attempt to turn

the amplifier back on. Doing so is likely to result in severe damage to amplifier components.

2. If the plate current again starts to rise while the amplifier is warming up, investigate and resolve the problem before attempting to turn the amplifier on again.
3. Fix any problems in the bias-control circuitry.
4. When you are certain that you have taken care of the problem that caused the fault, turn the amplifier back on.

7.2 Troubleshoot Problems

Amplifier does not turn on; nothing happens when the ON switch is pushed

1. External AC wiring, a fuse, or a circuit breaker may be open. Check and correct wiring, replace fuse, or reset circuit breaker.
2. The amplifier cover may not be in place or properly secured or the cover safety interlock may be open. Ensure that the cover is in place and all screws are securely inserted.
3. One or more connectors may be loose. Check that all of the transformer connectors are securely attached, that the 3x3 molex connector at the back of the amplifier is fully engaged, and that the two connectors between the transformer and the HV power supply boards are firmly inserted.
4. Fuse F1–F3 may be open or missing. Check fuses with an ohmmeter. Replace any blown fuses with fuses of the same size.
5. The step-start resistor may be open. Check the resistor. If it is damaged, replace it.

Amplifier turns on but no HV is indicated by the multimeter LED bargraph

1. The multimeter selector switch may be in the wrong position (example: Ip). Set the switch to the correct position.
2. The transformer may be plugged into the power supply incorrectly. Check the power-supply wiring and connectors to ensure that the input and output connectors and the voltage taps are set properly.
3. An HV circuit fault may exist. Check the line voltage.
4. The HV sampling resistor in the power supply may be damaged. Contact RF Concepts technical support.

Amplifier turns on but HV reading is low as indicated on the multimeter bargraph	The plate voltage to the power supply may be too low. Check the line voltage and confirm that the tap is set correctly.
Amplifier turns on but time delay does not complete and WAIT LED does not turn off	The timing circuitry on the control board may be damaged or defective. Contact RF Concepts technical support.
Amplifier turns on and time delay completes but amplifier does not transmit	The T/R control-line (key-line) connection to the amplifier may be faulty. 1. Confirm that the key line is inserted into the correct jack on the back of the amplifier. 2. Confirm that the key line is connected to the correct port on the transceiver and that amplifier-keying is enabled. 3. If the tube current has exceeded 2.5 A, follow the resolution instructions for "Fault type 2," page 7–2 and "Fault type 5," page 7–3. 4. Confirm that the cable is good. 5. Confirm, with the multimeter switch in the Ip position and the amplifier keyed with no RF, that plate current is drawn.
Amplifier operates properly, then turns off completely	The tube current may exceed ~2.5 A. See the resolution instructions for "Fault type 4," page 7–3.
Amplifier transmits but red grid LED lights often	The amplifier may be overdriven or incorrectly tuned; most likely the load control is set too low. Reduce the transceiver output and adjust the tune and load controls to maximize efficiency with minimum grid lights.
When switching from STBY to OPR mode, receive signals disappear or are severely attenuated	1. The RELAY (T/R) control cable from the transceiver may be shorted. Check the cable to ensure that it is switching properly. Replace it if needed.

	2. The transceiver may be locked in transmit. Ensure that the transceiver is properly switching between TRANSMIT and RECEIVE modes. For assistance, see the transceiver manual.
When amplifier is in STBY or RECEIVE mode, plate current is indicated	The tube bias supply or T/R bias switch may be faulty. Contact RF Concepts technical support.
Distorted SSB signal; grid bias is unexpectedly decreasing	1. The RF drive from the transceiver may be excessive and/or amplifier loading may be insufficient. Decrease drive from the transceiver. Recheck the amplifier tuning. 2. The coaxial connector, coax feed line, antenna feed point balun, tuner, or antenna trap may be arcing on voice peaks. Replace the faulty components. 3. RF feedback may exist from the antenna into the transceiver via the transceiver power cord, microphone or key cable, or other unshielded station patch cables. Ensure that all power cords, microphone and key cables, and other cables are properly shielded and grounded. 4. The station RF ground may be poor. Ensure that the amplifier and transceiver have a proper RF ground.
Required drive to maintain 1500 W is steadily increasing	The tube may be aging. Contact RF Concepts technical support to determine whether the tube needs to be replaced.

Terminology

NOTE: For detailed explanations of the following terms, see various publications including the latest *American Radio Relay League (ARRL) Handbook*.

A

AB1 — Modulation class AB1. Class that provides good linearity in a push-pull configuration.

AC — Alternating current. Electric current whose magnitude and direction vary with time.

ALC — Automatic Level Control. Technology that automatically controls output power.

ampere — Unit of electric current.

ARRL — American Radio Relay League. US national organization of amateur radio operators. For more information, go to **www.arrl.org**.

AWG — American wire gauge. Standard method of denoting wire diameter.

C

CW — Continuous wave. Electromagnetic wave of constant amplitude and frequency.

D

dB — Decibel. Logarithmic unit of measure of the power of sound relative to a reference level.

E

EBS — Electronic bias switching. A form of switching that increases negative grid 1 voltage in pauses in speech or between Morse code elements, resulting in reduced standing bias on the tube.

exciter — Radio that provides RF drive for the amplifier to operate. The transmitter portion of the transceiver.

F

FCC — Federal Communications Commission. For more information, go to **www.fcc.gov**.

FM — Frequency modulation. Modulation scheme in which information is conveyed over a carrier wave by variations in frequency.

FSK — Frequency-shift keying. Type of frequency modulation in which information is conveyed by shifts in the output frequency between predetermined values.

H

HF — High frequency. Radio frequency within the range 3–30 MHz.

HV — High voltage. Electrical circuit in which the voltage used presents risk of both electric shock and electrical arcing.

Hz — Hertz. One periodic event per second.

I

Ip — Idling plate current, in amperes. Plate current measured when the amplifier is keyed and RF is not present.

K

key — Signal from the radio to the amplifier that instructs the amplifier to switch from RECEIVE to TRANSMIT mode because the radio is ready to generate RF power. The (programmable) delay between keydown and RF out is generally 8–12 ms. When the amplifier is keyed, it is in State 5.

kV — kilovolt. 1000 V.

kVA — kilovolt–ampere. Unit of electrical power equal to 1000 volt–amperes, where 1 volt–ampere is the power dissipated when 1 volt produces a current of 1 ampere. 1000-W capability. kVA * 0.8 = kilowatts.

kW — Kilowatt. 1000 W.

L

LED — Light-emitting diode. Semiconductor diode that emits incoherent narrow-spectrum light, providing a form of electroluminescence.

LV — Low voltage. Electrical circuit in which the voltage used presents risk of electric shock but only minor risk of electrical arcing.

M

mA — Milliampere. 10^{-6} A.

MHz — Megahertz. 10^{6} Hz.

O

OPR — Operate.

P

PCB — Printed circuit board. Board that mechanically supports and electrically connects electronic components.

PEP — Peak envelope power. Average power supplied to the antenna transmission line by a transmitter during one RF cycle at the crest of the modulation envelope under normal operating conditions.

PSK — Phase-shift keying. Digital modulation scheme in which information is conveyed by changes, or modulations, in the phase of a reference signal.

Q

QSK — Quick-shift keying. Digital modulation scheme in which the transmitter is on only for the duration of each dot or dash and switches to RECEIVE mode between each dot or dash, allowing the operator to hear any signal being sent.

R

RCA — Radio Corporation of America. Also a type of interconnecting plug.

RF — Radio frequency. Frequency within the range 3 Hz to 300 GHz.

RG-x/x — Coaxial cable type.

RMS — Root mean square. Statistical measure of the magnitude of a varying quantity such as a wave.

RTTY — Radio teletype. Telecommunications system consisting of two or more teleprinters using radio as the transmission medium.

S

SSB — Single sideband. Modulation scheme that refines upon amplitude modulation.

SSTV — Slow-scan television. Picture-transmission method for transmitting and receiving static pictures via radio.

STBY — Standby. Mode in which an electronic appliance is turned off but under power and ready to activate on command.

SWR — Standing-wave ratio. Ratio of the amplitude of a partial standing wave at an antinode (maximum) to the amplitude at an adjacent node (minimum). Measure of antenna and feedline efficiency.

T

T/R — Transmit /receive.

transceiver — Device that has both a transmitter and a receiver within the same circuitry or chassis.

U

UHF — Ultra-high frequency. Radio frequency within the range 300–3000 MHz (3 GHz).

US — United States.

V

VAC — Volts of alternating current.

VDC — Volts of direct current.

VHF — Very high frequency. Radio frequency within the range 30–300 MHz.

VSWR — Voltage standing-wave ratio. Example: If VSWR = 1.2:1, the maximum standing-wave amplitude is 1.2 times greater than the minimum standing-wave amplitude.

Schematics

NOTE: The following pages contain detailed schematics for the Alpha 8406 linear amplifier.